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SANDIA NATIONAL LABORATORIES
WASTE ISOLATION PILOT PLANT

Analysis Plan For Deriving Radionuclide Inventory Information for Performance Assessment Calculations: Compliance Recertification Application

Task 1.3.5.1.2.1

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1. INTRODUCTION AND OBJECTIVES

In 1996 the Department of Energy (DOE) completed a performance assessment (PA) calculation for the Waste Isolation Pilot Plant (WIPP). The PA was part of the Compliance Certification Application (CCA) submitted to the Environmental Protection Agency (EPA) to demonstrate compliance with the radiation protection regulations of 40 CFR 191 and 40 CFR 194. As required by the WIPP Land Withdrawal Act (Public Law 102-579), DOE is required to submit documentation to EPA for the recertification of the WIPP every five years in order to continue operating the site. This will require that a Compliance Recertification Application (CRA) be prepared and submitted to the EPA by November 2003.

This Analysis Plan (AP) discusses the methodology that will be used by Sandia National Laboratories (SNL) to determine the WIPP repository radionuclide inventory information for use in the Performance Assessment (PA) calculation for the CRA.

1.1 BACKGROUND

Environmental radiation protection standards for management and disposal of spent nuclear fuel, high-level and transuranic radioactive wastes as defined in 40 CFR 191 require human intrusion scenarios to be included in the performance assessment calculations for repositories. Five distinct human intrusion scenarios that impact release from the repository are defined for the WIPP PA. Four of these involve a single drilling intrusion that occurs at either 350 or 1,000 years after repository closure. There are two types of drilling intrusions that are considered: 1) a borehole is drilled through a single waste panel and intersects a pressurized brine pocket located approximately 250 meters below the repository, and 2) a borehole is drilled into the repository but does not intersect a brine pocket. One multiple intrusion scenario is considered.

For scenarios that involve a drilling intrusion into the repository, release mechanisms include cuttings, cavings, spallings, and direct brine release (if brine is present). In order to calculate the extent of release due to these mechanisms, an estimate of the radionuclide content, expressed as the dose surrogate (called EPA Units), of the waste encountered via drilling is required.

Determination of the radionuclide content of the waste encountered via drilling is problematic because it is uncertain. The radionuclide content of waste streams going into the WIPP repository is uncertain, and the loading of those waste streams into the repository is uncertain. The EPA has offered guidance about how to handle this uncertainty. They state that in the absence of a waste loading plan for the repository, random waste emplacement should be assumed.

Therefore, following EPA guidance, it is assumed that waste is emplaced randomly in the repository and the probability of encountering any given waste stream in a drilling intrusion is directly proportional to the volume of that waste stream in the repository.

1.2 OBJECTIVES

The purpose of this Analysis Plan (AP) is to describe the process that SNL will follow when calculating the radionuclide inventory parameters that are used in the WIPP PA. These parameters are defined in Table 1.

Table 1: Radionuclide Inventory Information Used in WIPP Performance Assessment

Description	Name	Application
WIPP-Scale Initial Radionuclide Inventory In Curies	INVCHD and INVRHD for the following materials: AM 241; AM 243; CF 252; CM 243; CM 244; CM 245; CM248; CS 137; NP 237; PA 231; PB 210; PM 147; PU 238; PU 239; PU 240; PU 241; PU 242; PU 244; RA 226; RA 228; SR 90; TH 229; TH 230; TH 232; U 233; U 234; U 235; U 236; U 238	Input as parameters to PANEL
WIPP-Scale Initial Radionuclide Inventory In Curies	INVCHD and INVRHD for the following materials: AM241L, TH230L, PU238L, U234L, PU239L	Input as parameters to NUTS
Waste Unit Factor	WUF for the material: BOREHOLE	Input to CCDFGF
Waste Stream Information	For each waste stream, the probability of encountering that waste stream during drilling and the total EPA Units in that waste stream at 100, 125, 175, 350, 1000, 3000, 5000, 7500, and 10000 years.	Transferred in a file to CCDFGF for calculation of cuttings releases

This plan includes the strategy for conducting, documenting, and qualifying the calculations associated with the update of these parameters. Also included in this AP are discussions of applicable Nuclear Waste Management Program (NWMP) Procedures, personnel assignments, training requirements, schedule, and deliverables.

2. APPROACH

For the CRA, radionuclide inventories that are input for the work described in this AP will be gathered and qualified by Los Alamos National Laboratory (LANL) under AP-092, *Analysis Plan for Transuranic Waste Baseline Inventory Report (TWBIR), Revision 4*. LANL will provide radionuclide activity information for each waste stream in the TWBIR as well as WIPP-Scale radionuclide inventory information. SNL will use both the waste stream information and the WIPP-scale information as described below.

2.1 WASTE UNIT FACTOR

The waste unit factor (WUF), also referred to as the “Unit of Waste,” is defined in the CCA as the number of millions of curies of alpha-emitting transuranic radionuclides with half-lives longer than 20 years destined for disposal in the WIPP repository (DOE 1996). Computation of a new waste unit factor based on the updated inventory information provided by LANL is required for the CRA. This computation is performed using the following equation (Sanchez, February 1997):

$$f_w = \frac{\sum W_i}{10^6 Ci}$$ Equation 1

where:

f_w is the Waste Unit Factor , and

W_i is the WIPP-scale activity in curies (Ci), for α –emitting TRU repository wastes having half-lives greater than or equal to 20 years.

This calculation uses the WIPP-scale inventory provided by LANL. Documentation of the WUF value for the WIPP transuranic waste will be generated for its inclusion into the WIPP CRA Parameter Database. Entry of the WUF into the WIPP CRA Parameter Database is to be managed in accordance with the specific procedure SP 9-5, *Parameter Data Entry*.

2.2 IDENTIFICATION OF RADIONUCLIDES THAT DOMINATE RELEASE

Because there are over one hundred radionuclides contained in the TRU waste destined for WIPP, it is important to identify which radionuclides are going to be the major contributors to potential releases so that performance assessment calculations can focus on modeling those radionuclides. Based on the TWBIR Revision 3 data, analysts identified which radionuclides were most important for modeling performance assessment used in the CCA. However, with udated data from the generator sites, the exercise of identifying which radionuclides will dominate release must be repeated for the CRA.

The method for identifying which radionuclides will dominate release has been documented in Sanchez et. al. (1997). The method will not be altered for the CRA. In summary, the method involves calculating the percent contribution that each radionuclide makes to the EPA "Unit of Waste" (described above in Section 2.1). The percent contribution is calculated using the following equation:

$$f_i = \frac{100 \bullet W_i}{f_w \bullet 10^6 Ci}$$ Equation 2

where:

f_i is the percent contribution to the Waste Unit Factor from radionuclide i,

f_w is the Waste Unit Factor, and

W_i is the WIPP-scale activity in curies (Ci), for radionuclide i

Radionuclides are ranked based on their f_i value. The most important radionuclides are those required to account for 99% of f_w. This calculation uses the WIPP-scale inventory provided during the TWBIR 2003 update.

2.3 WIPP-SCALE INITIAL RADIONUCLIDE INVENTORY

Once the radionuclides that will be tracked in the performance assessment have been identified, the initial WIPP-scale inventory (in Ci) for those radionuclides will be extracted from the LANL data and entered into the WIPP CRA Parameter Database. The parameters are INVCHD and INVRHD for the materials: AM 241; AM 243; CF 252; CM 243; CM 244; CM 245; CM248; CS 137; NP 237; PA 231; PB 210; PM 147; PU 238; PU 239; PU 240; PU 241; PU 242; PU 244; RA 226; RA 228; SR 90; TH 229; TH 230; TH 232; U 233; U 234; U 235; U 236; U 238. Entry into the WIPP CRA Parameter Database is to be managed in accordance with the specific procedure SP 9-2, *Parameters*. These parameters are used in the PANEL code to calculate the radionuclide source term.

For NUTS, "lumped" radionuclide inventories are used. The "lumped" radionuclide inventories are sums of activities for radionuclides that will be transported at the same rate in the NUTS calculation. The grouping of radionuclides for the CCA was:

Activity of U234 and U233 combined to produce values for U234L

Activity of Am241 and Pu241 combined to produce values for AM241L

Activity of Pu239, Pu240, and Pu242 combined to produce values for PU239L

Activity of Pu238 is the same as the activity for PU238L

Activity of Th230 and Th299 combined to produce values for TH230L

This grouping is not expected to change for the CRA.

2.4 RADIONUCLIDE PRODUCTION AND DECAY

Human intrusion scenarios for the WIPP PA involve random drilling events that can occur any time during the 10,000-year regulatory period specified in 40 CFR 191. As a result, radionuclide inventory information as a function of time must be available. For the CCA, the radionuclide inventory was calculated at discrete intervals over the 10,000-year regulatory period (100, 125, 175, 350, 1000, 3000, 5000, 7500, and 10000 years), and information for intrusions occurring between intervals was calculated via interpolation. The same approach will be used in the CRA. As a result, radioactive build-up and decay of the key radionuclides identified as a result of the activities described above in Section 2.2 must be calculated. Radioactive decay and production are calculated using analytical solutions to the Bateman equations. The time values start at the closure date of WIPP (calendar year 2033) and go up to the completion of the regulatory time limit of 10,000 years (i.e., calendar 12033).

2.5 RADIONUCLIDES ENCOUNTERED DURING DRILLING

The mechanisms that result in release of radionuclides during a human intrusion scenario require information about the radionuclides that would be encountered during drilling. For the WIPP performance assessment this information is quantified using the metric of EPA Unit EPA Units for each radionuclide. In order to understand EPA UnitEPA Units, one must be familiar with 40 CFR 191 which specifies release limits for TRU waste where a unit of waste is 10^6 αCi. For example, the release limit for Pu-239 is 100 αCi per unit of waste (10^6 αCi in the repository). Therefore, if there are 3.44 x 10^6 total αCi disposed in the repository, 344 Ci of the Pu-239 isotope can be released over the 10,000 year regulatory time period. The quantity that could be released according to the regulation is referred to as the EPA Unit. For the plutonium example above, a EPA Unit is 344 Ci of the isotope. One can calculate the activity of the isotope in EPA Units using the following equation:

$$E_i = \frac{w_i}{f_w \bullet r_i}$$ Equation 3

where:

E_i is the radionuclide activity expressed in EPA Units for radionuclide i,
r_i is the release limit from 40 CFR 191 for radionuclide i,
f_w is the Waste Unit Factor, and
w_i is the waste-stream-scale activity in curies (Ci), for radionuclide i

For the WIPP PA, the activity in EPA Units at each time interval of interest of each of the major radionuclides (as identified in Section 2.2) in each waste stream is calculated. Then, the activity of the entire waste stream (at the time interval) in EPA Units is calculated as:

$$E_{ws} = \sum E_i$$ Equation 4

where:

E_{ws} is the radionuclide activity of a waste stream expressed in EPA Units,
E_i is the radionuclide activity expressed in EPA Units for radionuclide i.

Once the activity of each waste stream in the metric of EPA Units is determined at each time interval, the probability of encountering each stream during a drilling intrusion is calculated as:

$$p_{ws} = \frac{v_{ws}}{V}$$ Equation 5

where:

p_{ws} is the probability of encountering a waste stream during a drilling intrusion,
v_{ws} is the volume of an individual waste stream, and
V is the total volume of waste in the repository.

This information is then used in the WIPP PA to calculate potential releases from cuttings.

3. TASKS

Task #	Task Description	Responsible Individual(s)	Deliverable(s)	Estimated Start Date	Target Date
1	Review available TWBIR information on radioactivity inventory for WIPP-Scale final waste forms.	L.C. Sanchez P.S. Downes	Submit documentation to records center.	2/17/03	2/24/03
2	Compute Waste Unit Factor (WUF) for TWBIR WIPP-Scale radionuclide inventory.	L.C. Sanchez P.S. Downes	Submit documentation to records center.	2/17/03	2/24/03
3	Compute EPA Units for TWBIR WIPP-Scale radionuclide inventory. Perform ranking analysis to identify most significant radionuclides.	L.C. Sanchez P.S. Downes	Submit documentation to records center.	2/17/03	2/24/03
4	Review available TWBIR information on radioactivity inventory for waste stream level final waste forms.	L.C. Sanchez P.S. Downes	Submit documentation to records center.	2/17/03	3/03/03
5	Perform analyses of CH-TRU and RH-TRU final form waste streams with EPAUNI computer code.	L.C. Sanchez P.S. Downes	Results to be documented in final EPAUNI Analysis Report.	3/03/03	3/10/03
6	Review of computational results from EPAUNI computer code.	L.C. Sanchez P.S. Downes	Results to be documented in final EPAUNI Analysis Report.	3/03/03	3/10/03
7	Present documentation (paper report) of all data results in final report.	L.C. Sanchez P.S. Downes	Submit EPAUNI Analysis Report to records center.	3/10/03	3/31/03

4. SOFTWARE LIST

EPA UNI Version 1.14
POST_EPAUNI 1.15

5. DOCUMENTATION, QA REQUIREMENTS, AND RECORDS

5.1 TRAINING

Training will be performed in accordance with the requirements in NP 2-1, *Qualification and Training*.

5.2 PARAMETER DEVELOPMENT AND DATABASE MANAGEMENT

Selection and documentation of parameter values will follow NP 9-2, *Parameters*. The data entry is to be managed in accordance with the specific procedure SP 9-5, *Parameter Data Entry*.

5.3 COMPUTER CODES

New or revised computer codes that will be used in the analyses will be qualified in accordance with NP 19-1, *Software Requirements*. The platform on which the codes will be run is the COMPAQ Alpha, Open VMS AXP, Version 7.3-1.

5.4 ANALYSIS AND DOCUMENTATION

Documentation will meet the applicable requirements in NP 9-1, *Analyses* Records will be submitted to the records center using NP 17-1 *Records*.

The finalized radionuclide inventory analysis report will be generated in a format consistent with that previously used in the CCA (Sanchez et. al., 1996)

5.5 REVIEWS

Reviews will be conducted and documented in accordance with NP 6-1, *Document Review Process* and NP 9-1, *Analyses* as appropriate.

6. SPECIAL CONSIDERATIONS

None

7. REFERENCES

DOE (U.S. Department of Energy) 1996. Title 40 CFR Part 191 *Compliance Certification Application for the Waste Isolation Pilot Plant.* DOE/CAO-1996-2184. U.S. Department of Energy. Carlsbad, NM.

Sanchez, February 1997, Sanchez, Lawrence C., Jennifer Liscum-Powell, Jonathan S. Rath, and Holly R. Trellue. "*WIPP PA Analysis Report for EPAUNI: Estimating Probability Distribution of EPA Unit Loading in the WIPP Repository for Performance Assessment Calculations"* Version 1.01. February 17, 1997.